

**THE USE OF UNDERWATER DYNAMOMETRY  
TO EVALUATE TWO SPACE SUITS**

**Final Report**

**NASA/ASEE Summer Faculty Fellowship Program--1989**

**Johnson Space Center**

**Prepared By:**

**W. G. Squires Ph.D**

**Academic Rank:**

**Professor**

**University & Department:**

**Texas Lutheran College  
Department of Biology  
Sequin, Texas**

**NASA/JSC**

**Directorate:**

**Space and Life Sciences**

**Division:**

**Man Systems**

**Branch:**

**Crew Station**

**JSC Colleague:**

**Mike Greenisen Ph.D.**

**Date Submitted:**

**August 9, 1989**

**Contract Number:**

**NGT 44-001-800**

## ABSTRACT

Four Astronauts were instrumented and donned one of three EVA suits. The currently in use shuttle suit (STS), the Mark III (MK3), and the AX5. The STS was used as the comparison suit because of approved status. Each subject performed ten different exercise in each suit in three different manners(static,dynamic and fatigue) in two different environments,WETF and KC-135( KC-135 not completed as of this report). Data were recorded from a flight qualified underwater dynamometer(Cybex power head) with a TEAC multichannel recorder/tape and downloaded into the VAX computer system for anaylsis. Also direct hard copy strip chart recordings were made for backup comparisons. Data were anaylized using the ANOVA procedure and results were graphed and reported without intrepertation to the NASA/JSC ABL manager.

## INTRODUCTION

The protective garment that the astronaut will wear during EVA activities has long been and continues to be a major concern for the manned space program. The shuttle suit (STS) has been up to this point the workhorse of the program. With the advent of the space station and the required extended EVA activity involved, new designs with unique changes have been sought. Thus two new prototype suits have been developed the Mark III (MK3), and the AX5.

## PURPOSE

The purpose of this study was to investigate the capabilities of the three suits while performing ten different activities in three different modes under two different conditions. (appendix#1).

## METHODS

Four male astronauts were assigned to perform ten different exercises in three different modes under two different environmental conditions. Subjects donned one of the suits entered the WETF and were transported by the safety divers to the dynamometer station. On the command of the test director the subject initiated the activity in the sequence of the protocol. The static exercise was done first, followed by the dynamic, then the fatigue. There was a mandatory rest of ten minutes between exercises. Data was collected on a TEAC recorder and then later downloaded to the Vax system for later analysis. A simultaneous hard copy recording was made on all subjects on all trials. Data was collected and analyzed using the double blind procedure to reduce experimenter bias.

## RESULTS

All data was double checked by two independent investigators and entered into a Macintosh II computer data base. Data was analyzed using ANOVA for independent samples (suits). Analysis was run on each exercise and each mode (static, dynamic, and fatigue). Mean forces and standard errors were graphically developed. All results were presented confidently to the manager of the ABL lab for interpretation and dissemination.

# ADVANCE SUIT TEST PROGRAM FILENAME



## SUBJECT

- DH
- SC
- JH
- JR

## SUIT

- SHUTTLE SUIT → STS
- MARK III → MK3
- AX5 → AX5

## ENVIRONMENT

- WETF → WET
- KC-135 → KC

## EXERCISE

- SHOULDER ADDUCTION → 1
- EVA RATCHET WRENCH CRANK → 2
- SHOULDER ROTATION-MED. INT. → 3
- ELBOW FLEXION → 4
- ELBOW EXTENSION → 5
- SHOULDER FLEXION → 6
- EVA RATCHET WRENCH PUSH → 7
- EVA RATCHET WRENCH PULL → 8
- SHOULDER ROTATION- Y-AXIS → 9
- SHOULDER ADDUCTION-FLEXION → 0

## TYPE

- STATIC → 1
- DYNAMIC → 2
- FATIGUE → 3

Inktonkoma, New York

POSITION ANGLE (DEG.)

CYBEX  
CALIBRATION

30 ft/lb  
CALIBRATION  
25 ft/lb  
FULL CALIBRATION

(-LBS)

Dual Channel CYBEX II

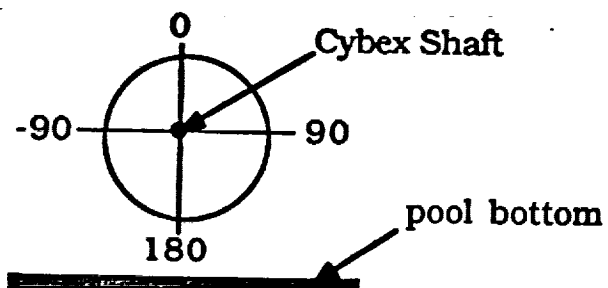
Cybex Division Lumex Inc R.C. Ink

90 ft/lb  
CALIBRATION  
90 ft/lb  
FULL CALIBRATION

TORQUE (FT.-LB)

This information pertains to the following two pages of Cybex exercises.

The reference system used for defining the range of motion for each exercise is as shown - looking down the dynamometer shaft from the crewmember exercise station



<u>Exercise</u>	<u>Static Position</u>	<u>Dynamic Range of Motion</u>
Shoulder Adduction	60°	45° to 135°
EVA Ratchet Wrench Crank	75°	45° to 135°
Shoulder Rotation - Med. Int.	-45°	0° to -110°
Elbow Flexion	-105°	180° to -45°
Elbow Extension	-75°	-45° to 180°
Shoulder Flexion	-80°	-45° to -135°
EVA Ratchet Wrench Push	15°	45° to -45°
EVA Ratchet Wrench Pull	-15°	-45° to 45°
Shoulder Rotation - Y Axis	-45°	0° to -90°